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Huang et al.

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(54) **PANEL ASSEMBLY AND ELECTRONIC DEVICE**

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(51) **Int. Cl.**

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G02B 5/00	(2006.01)
G02B 27/02	(2006.01)
G06F 3/00	(2006.01)
H04M 1/02	(2006.01)

(52) **U.S. Cl.**

CPC ***G02B 3/08*** (2013.01); ***G02B 27/027*** (2013.01); ***G06F 3/00*** (2013.01); ***H04M 1/0266*** (2013.01); *H04M 1/0283* (2013.01)

(58) **Field of Classification Search**

CPC G06F 1/16; G06F 1/1601; G06F 1/1626; G06F 1/1643; G06F 1/1658; G02B 27/01; G02B 27/14; G02B 27/22; G02B 27/2214; G02B 3/08

See application file for complete search history.

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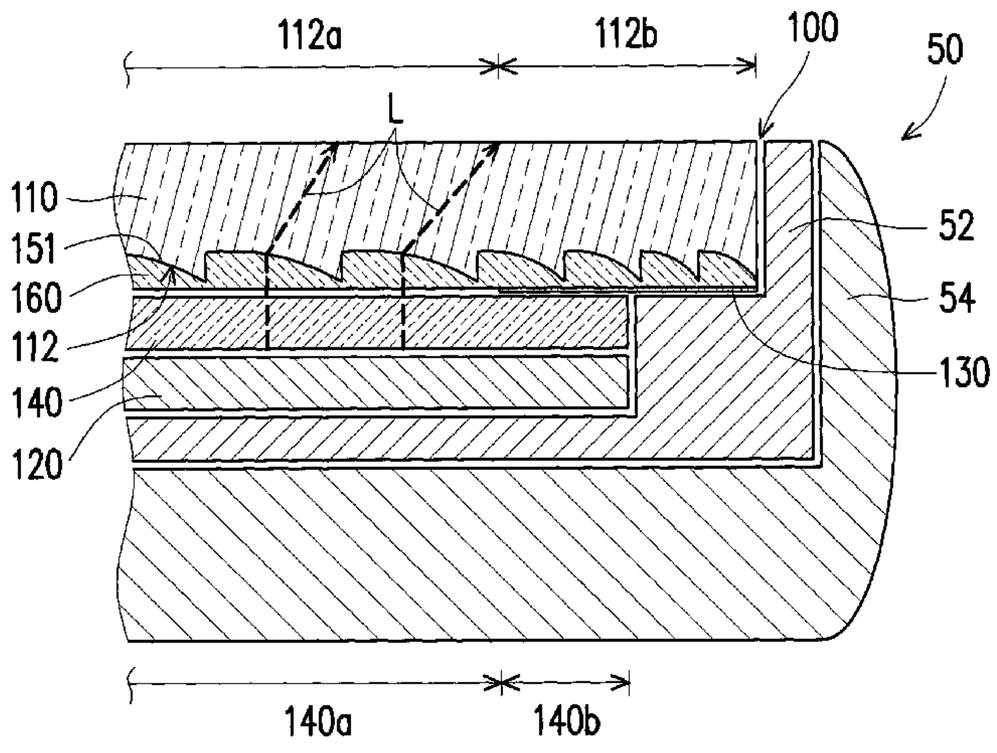
(57) **ABSTRACT**

A panel assembly includes a transparent cover, a display module, a decorative layer, and a Fresnel lens structure. The transparent cover has a lower surface. The display module is disposed under the lower surface. The decorative layer is disposed on the lower surface. The Fresnel lens structure is located above the display module. Besides, an electronic device includes a frame, a housing, and the above panel assembly, and the housing and the panel assembly are installed in the frame.

10 Claims, 5 Drawing Sheets



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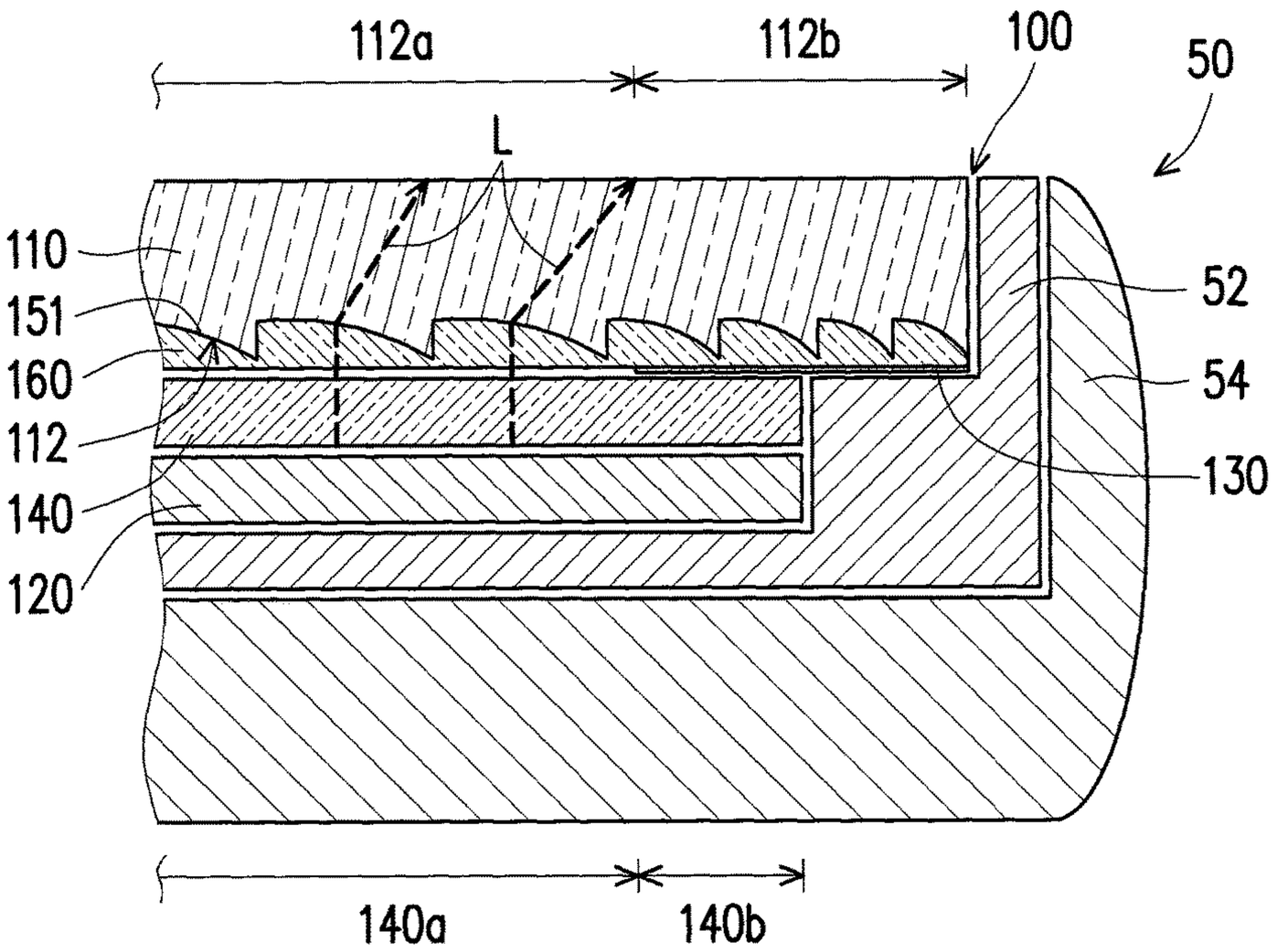
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FIG. 1A

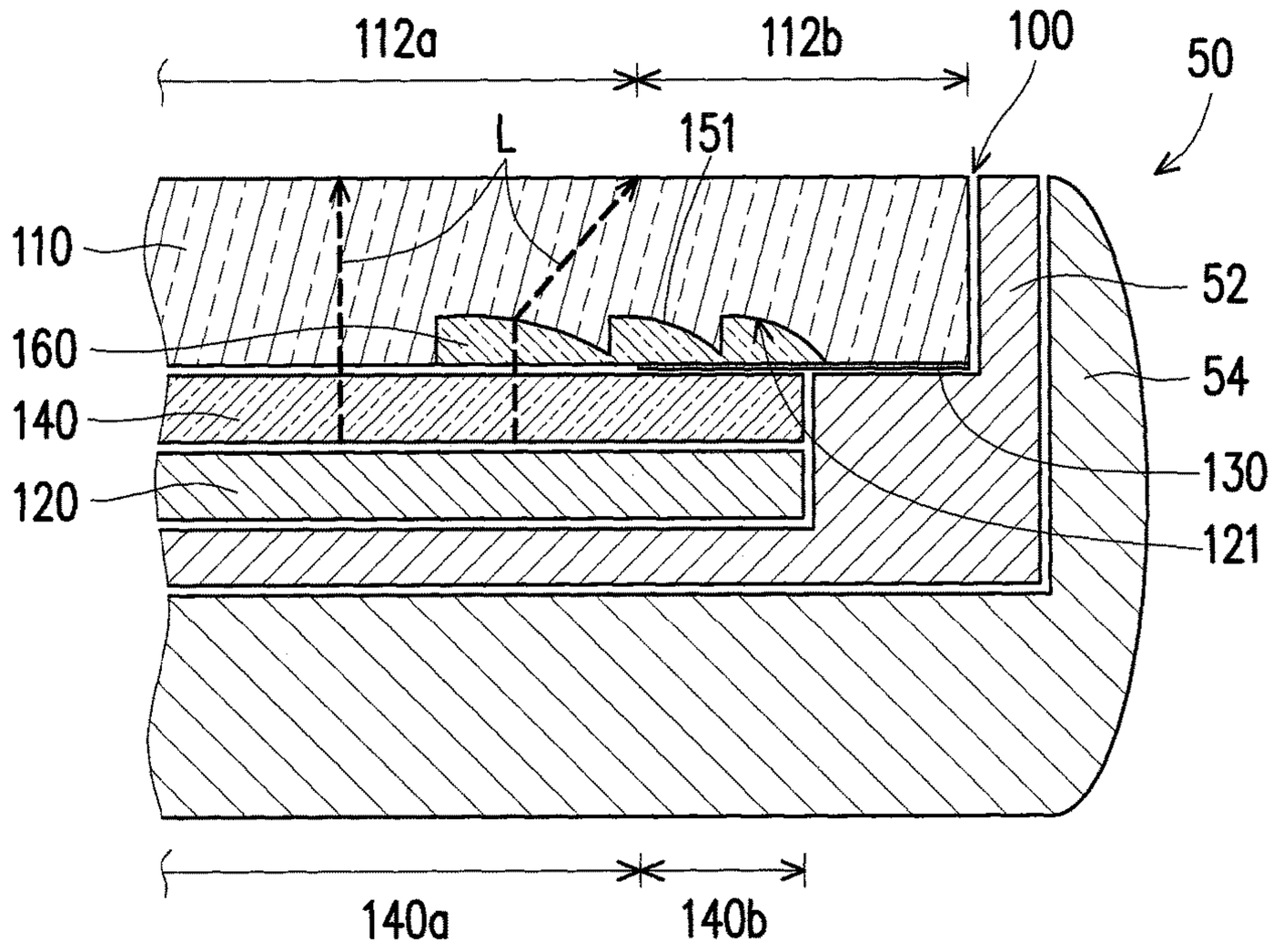
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FIG. 1B

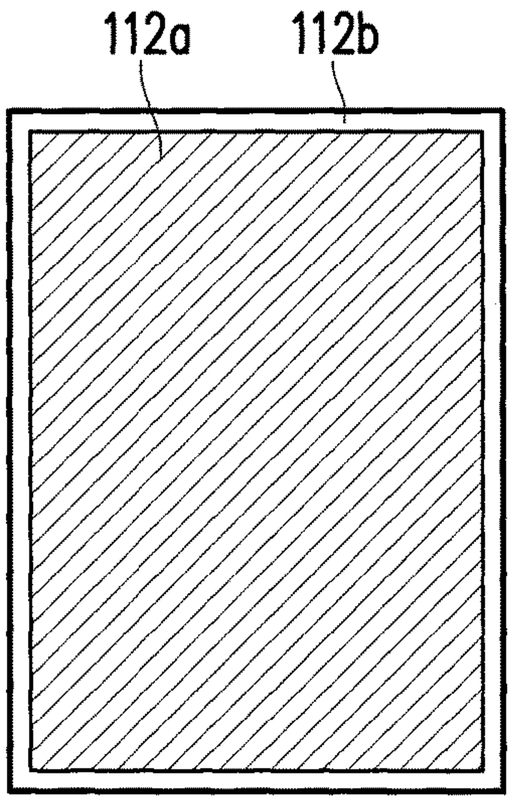
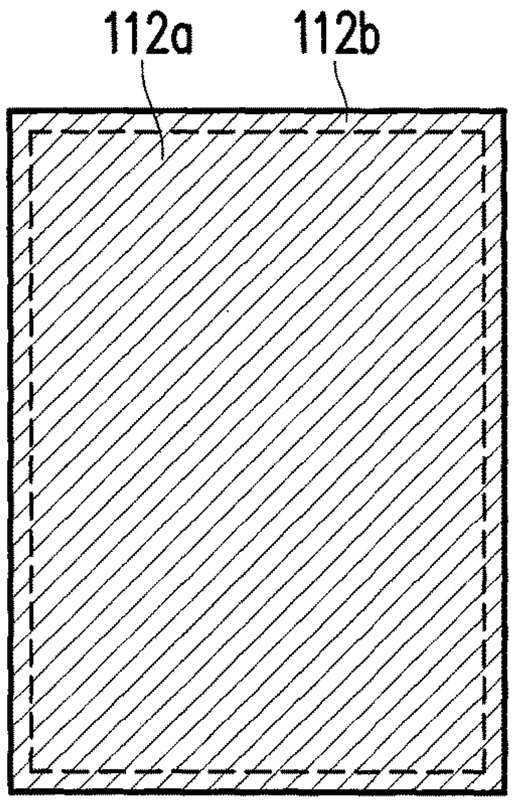


FIG. 2A



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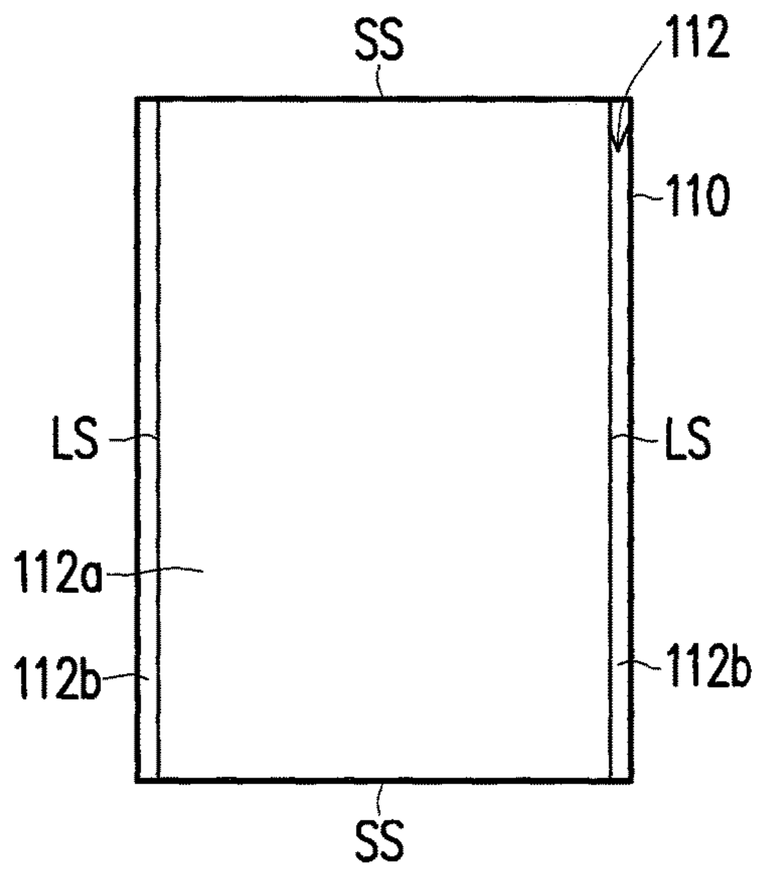
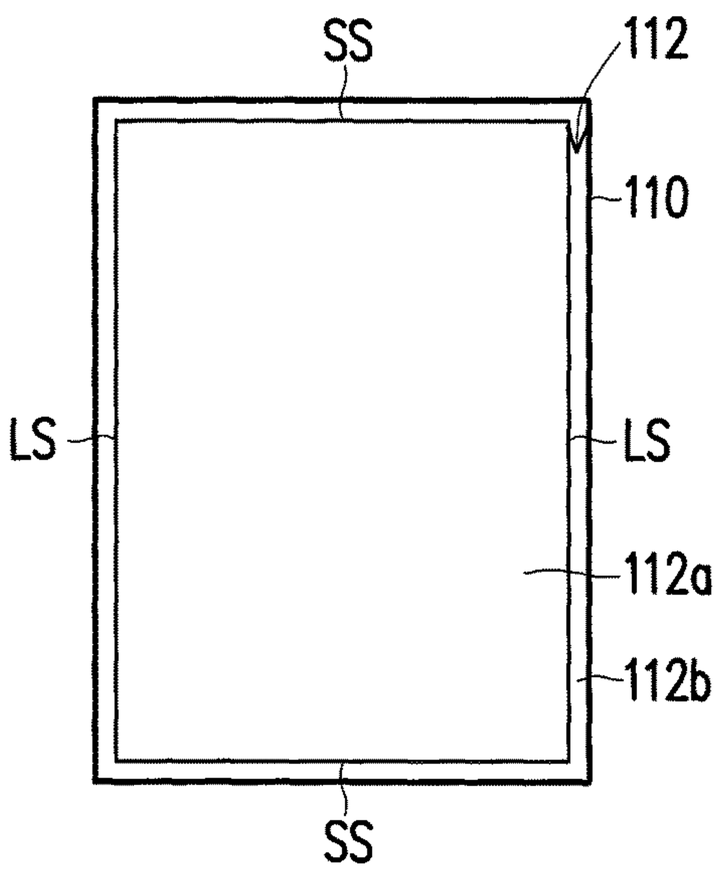


FIG. 2C



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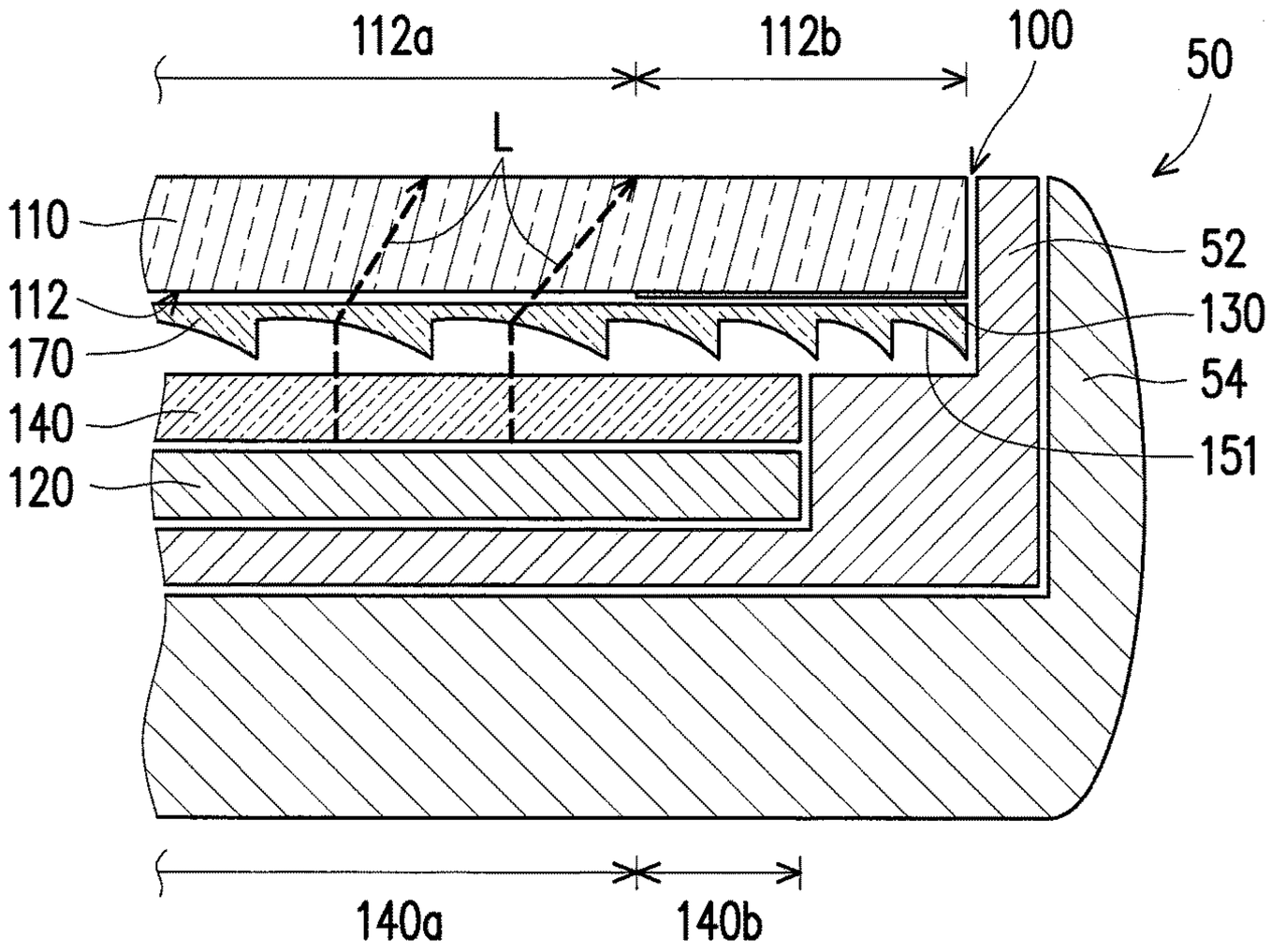
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FIG. 3A

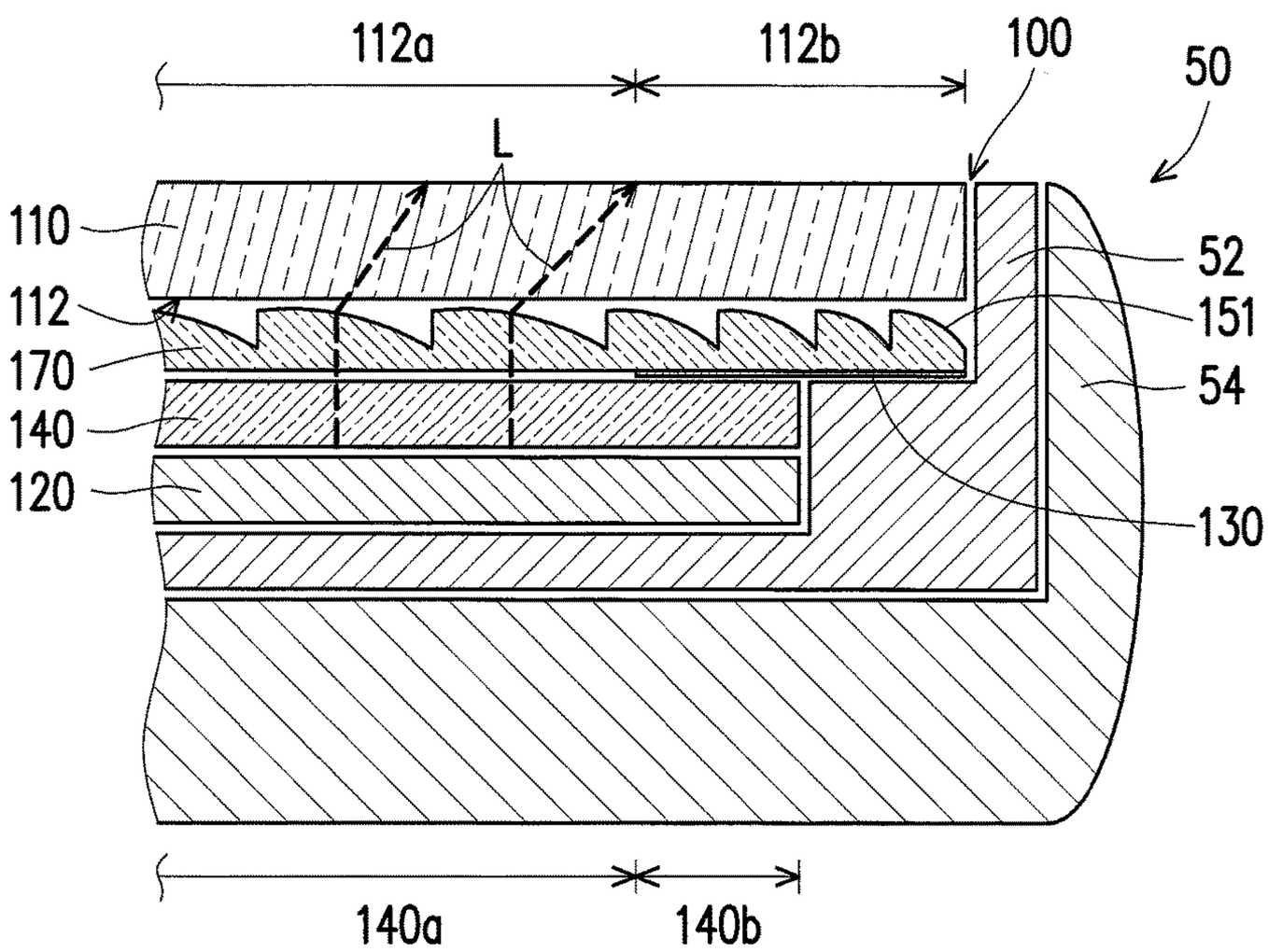
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FIG. 3B

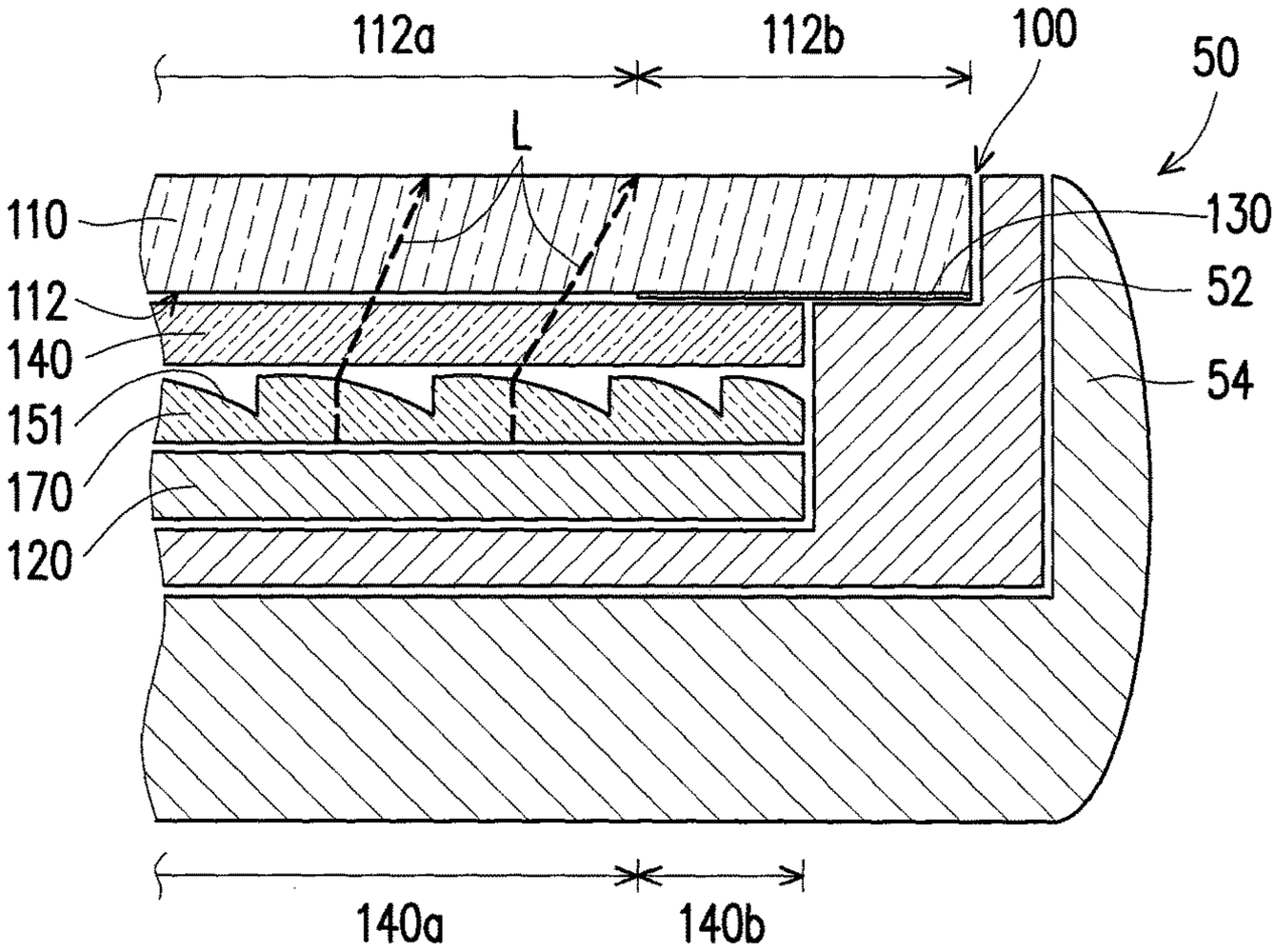
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FIG. 3C

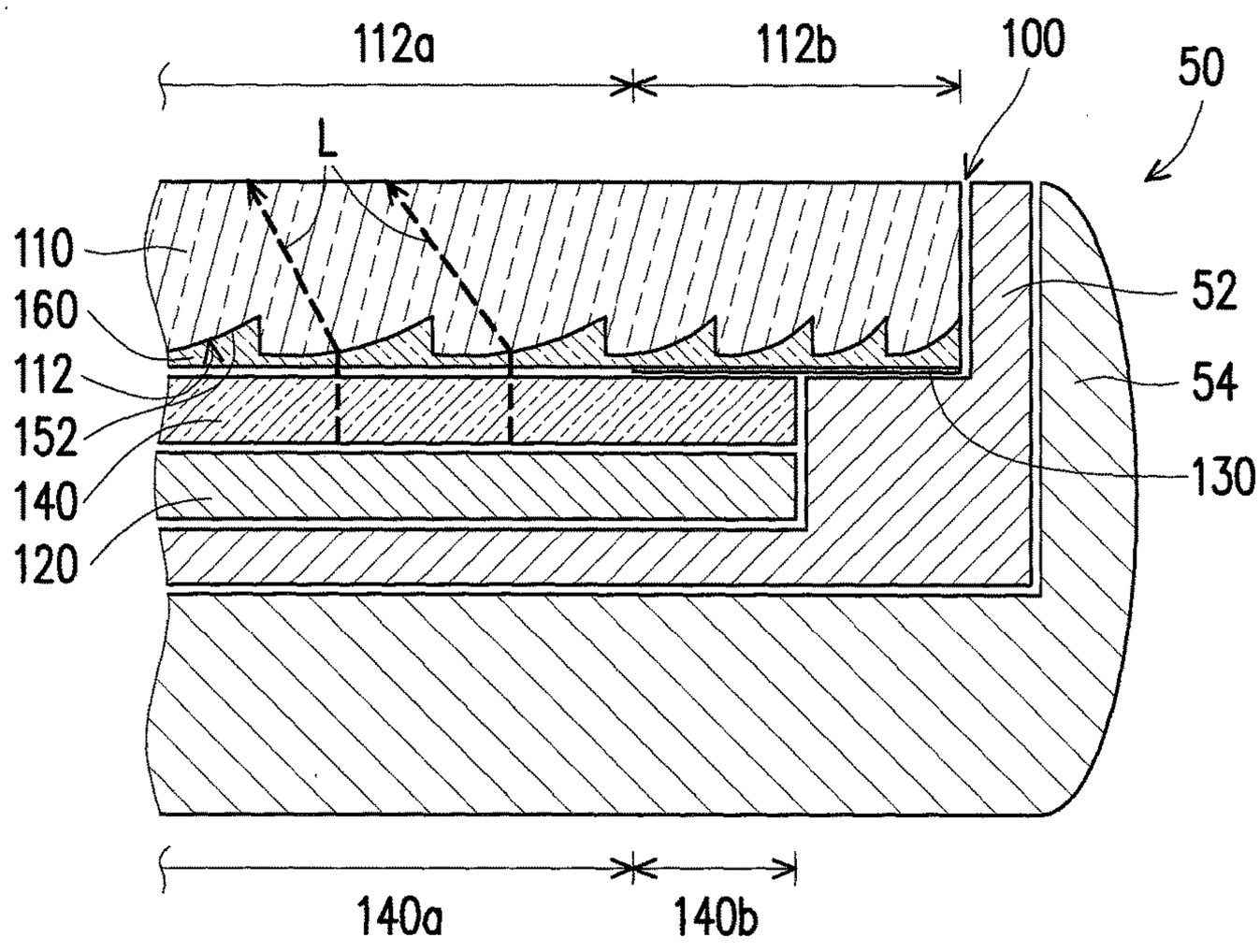
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FIG. 4

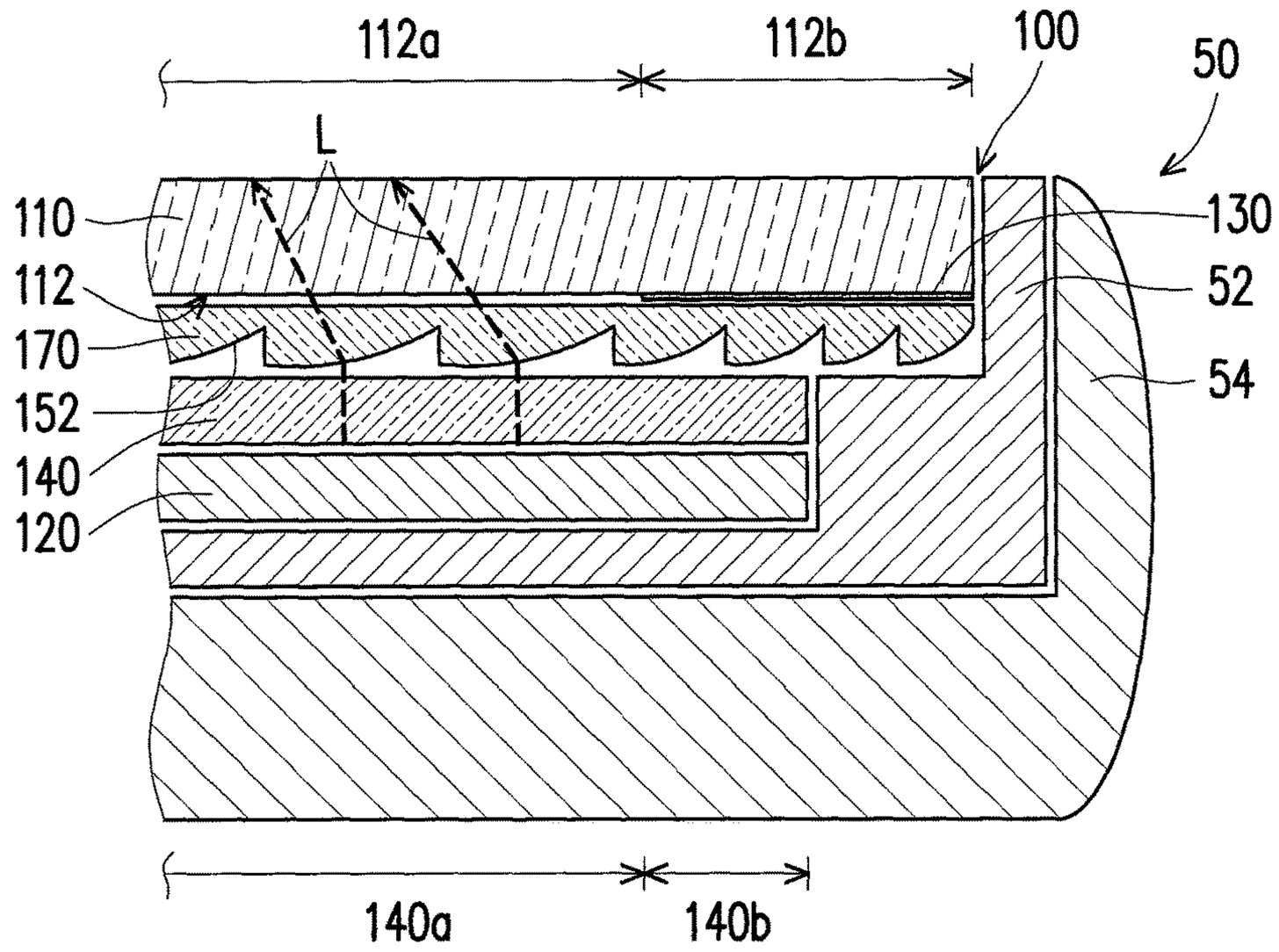
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FIG. 5A

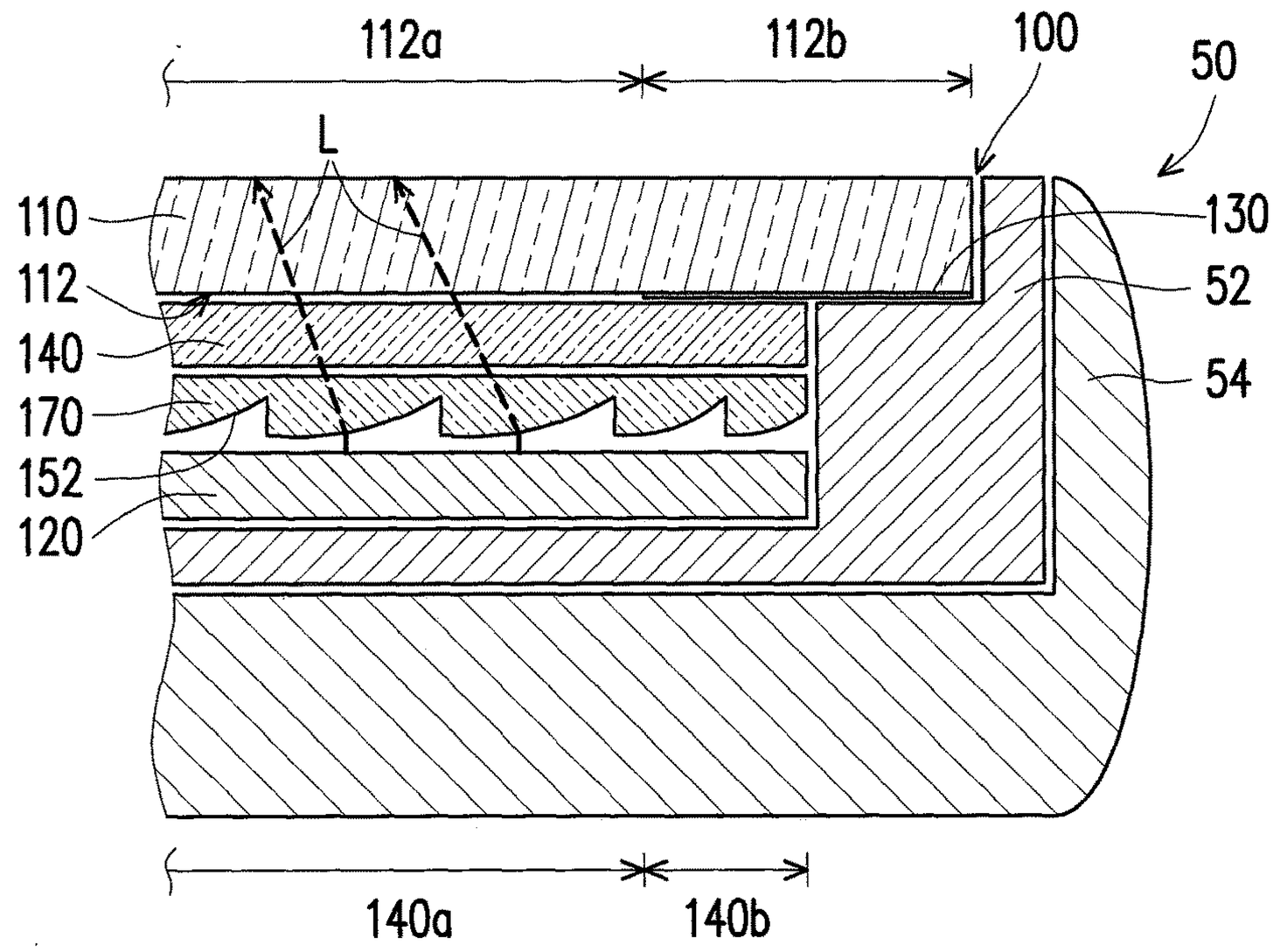
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FIG. 5B

PANEL ASSEMBLY AND ELECTRONIC DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The application relates to a panel assembly and particularly relates to a panel assembly having a touch function and an electronic device utilizing the panel assembly.

Description of Related Art

Electronic devices, such as smart phones and tablet computers, are very popular among the consumers for their versatile functions and thin and light designs. This type of electronic device is usually equipped with a panel assembly having a touch function. The panel assembly includes a transparent cover, a touch module, and a display module. Colored ink (black ink, for example) is applied around the lower surface of the transparent cover to form a decorative layer for covering a peripheral circuit of the touch module or other components that need to be hidden. In order to cover and shield the peripheral circuit of the touch module, borders formed by the decorative layer on two opposite sides of the lower surface of the transparent cover are necessary.

SUMMARY OF THE INVENTION

The application provides a panel assembly for visually narrowing or hiding a border formed by a decorative layer disposed on a transparent cover.

The panel assembly of the application includes a transparent cover, a display module, a decorative layer, and a Fresnel lens structure. The transparent cover has a lower surface. The display module is disposed under the lower surface. The decorative layer is disposed on the lower surface. The Fresnel lens structure is located above the display module.

The application provides an electronic device that includes a frame, a housing, and the panel assembly, wherein the housing and the panel assembly are installed in the frame.

Based on the above, according to the invention, the Fresnel lens structure changes the direction of an image light from the display module to visually enlarge the image generated by the display module or reduce a viewing angle range of the image displayed by the display module.

To make the aforementioned and other features and advantages of the application more comprehensible, several embodiments accompanied with drawings are described in detail as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a partial cross-sectional view of an electronic device having a panel assembly according to an embodiment of the invention.

FIG. **1**B is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

FIG. **2**A and FIG. **2**B are schematic views respectively showing images of a display module before and after being enlarged by a Fresnel lens structure of FIG. **1**A.

FIG. **2**C and FIG. **2**D are schematic views respectively showing a lower surface of a transparent cover according to two other embodiments of the invention.

FIG. **3**A is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

FIG. **3**B is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

FIG. **3**C is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

FIG. **4** is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

FIG. **5**A is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

FIG. **5**B is a partial cross-sectional view of an electronic device having a panel assembly according to another embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

With reference to FIG. **1**, in this embodiment, an electronic device **50** includes a frame **52**, a housing **54**, and a panel assembly **100**. The housing **54** and the panel assembly **100** are both assembled to the frame **52**. The panel assembly **100** includes a transparent cover **110**, a display module **120**, and a decorative layer **130**. The transparent cover **110** has a lower surface **112**. The display module **120** is disposed under the lower surface **112**. The decorative layer **130** is disposed on the lower surface **112**. The lower surface **112** of the transparent cover **110** has a central region **112***a* and a peripheral region **112***b* surrounding the central region **112***a*. The decorative layer **130** is disposed on the peripheral region **112***b* of the lower surface **112** to cover and shield a peripheral circuit of a touch module **140**.

In this embodiment, the panel assembly **100** configured for touch input further includes the touch module **140**. The touch module **140** is disposed between the transparent cover **110** and the display module **120**. The touch module **140** includes a transparent circuit region **140***a* and a non-transparent circuit region **140***b*. The peripheral region **112***b* substantially corresponds to the non-transparent circuit region **140***b* of the touch module **140**, and the decorative layer **130** covers the non-transparent circuit region **140***b*. The touch module **140** may be an additional touch module. That is, the touch module **140** and the display module **120** are separately fabricated and then assembled together. Alternatively, the touch module **140** may be a built-in touch module (including on-cell type or in-cell type). That is, the touch module **140** is fabricated simultaneously in the fabricating process of the display module **120**, so as to form the touch module **140** and the display module **120** integrally.

The panel assembly **100** further includes a Fresnel lens structure **151** disposed at a junction of the central region **112***a* and the peripheral region **112***b* for changing the direction of an image light L from the display module **120**. In particular, the periphery of the Fresnel lens structure **151** generates favorable effects in turning the image light L. The aforementioned Fresnel lens is an improved lens that is formed by forming a series of theoretically countless concentric lines on a traditional spherical lens, so as to achieve the same optical effects while thinning the lens thickness and saving the material.

In this embodiment, the Fresnel lens structure **151** is a diverging lens. The Fresnel lens structure **151** visually enlarges the image generated by the display module **120**, as indicated by the shaded portions in FIG. **2**A and FIG. **2**B. Therefore, the decorative layer **130** disposed on the peripheral region **112***b* is visually narrowed or hidden.

In this embodiment, the Fresnel lens structure **151** is disposed corresponding to the whole central region **112***a*. In another embodiment, as shown in FIG. **1**B, the Fresnel lens structure **151** can be disposed only at the junction of the central region **112***a* and the peripheral region **112***b*, not in other portions of the central region **112***a*.

In this embodiment, the Fresnel lens structure **151** may be formed on the lower surface **112** of the transparent cover **110**. In other words, in the process of fabricating the transparent cover **110**, the lower surface **112** of the transparent cover **110** is directly formed into a convex-concave structure to serve as the Fresnel lens structure **151**. Moreover, the panel assembly **100** may further include a transparent adhesive layer **160** covering the Fresnel lens structure **151** to make the Fresnel lens structure **151** even, and the decorative layer **130** is disposed on the transparent adhesive layer **160**.

In an embodiment, as shown in FIG. **1**B and FIG. **2**C, the central region **112***a* is rectangular and has a pair of long sides LS and a pair of short sides SS. The Fresnel lens structure **151** is disposed only along the pair of long sides LS. In another embodiment, as shown in FIG. **1**B and FIG. **2**D, the Fresnel lens structure **151** is disposed along the pair of long sides LS and the pair of short sides SS, and a curvature of a portion of the Fresnel lens structure **151** disposed on the pair of long sides LS is larger than a curvature of a portion of the Fresnel lens structure **151** disposed on the pair of short sides SS, such that the long sides LS generate a relatively strong refraction effect while the short sides SS generate a relatively weak refraction effect, thereby achieving a visual effect similar to the current 2.5D curved screen.

With reference to FIG. **3**A, unlike the embodiment of FIG. **1** where the Fresnel lens structure **151** is formed on the lower surface **112** of the transparent cover **110**, the panel assembly **100** of FIG. **3**A further includes a thin film **170**, and the Fresnel lens structure **151** is formed on a lower surface of the thin film **160**. The thin film **170** is fabricated independently and then disposed between the transparent cover **110** and the display module **120** and located under the lower surface **112** of the transparent cover **110** and the decorative layer **130**. In another embodiment, as shown in FIG. **3**B, the Fresnel lens structure **151** is formed on an upper surface of the thin film **160** while the decorative layer **130** is disposed on the lower surface of the thin film **170**. In another embodiment, as shown in FIG. **3**C, the thin film **160** with the Fresnel lens structure **151** thereon is disposed between the touch module **140** and the display module **120**.

With reference to FIG. **4**, unlike the embodiment of FIG. **1** where the Fresnel lens structure **151** is a diverging lens, a Fresnel lens structure **152** of FIG. **4** is a converging lens. Thus, visually a viewing angle range of the image displayed by the display module **120** is reduced to achieve an anti-peep effect.

With reference to FIG. **5**A, unlike the embodiment of FIG. **4** where the Fresnel lens structure **152** is directly formed on the lower surface **112** of the transparent cover **110**, the Fresnel lens structure **152** of FIG. **5**A is a thin film that is fabricated independently and then disposed under the lower surface **112** of the transparent cover **110** and the decorative layer **130**. In addition, with reference to FIG. **5**B, unlike the embodiment of FIG. **5**A where the Fresnel lens structure **152** is disposed between the transparent cover **110** and the touch module **140**, the Fresnel lens structure **152** of FIG. **5**A is disposed between the touch module **140** and the display module **140**.

In conclusion, according to the invention, the Fresnel lens structure is used to change the direction of the image light from the display module. If the Fresnel lens structure is a diverging lens, the image generated by the display module is enlarged visually to visually narrow or hide the decorative layer disposed on the peripheral region. If the Fresnel lens structure is a converging lens, the viewing angle range of the image displayed by the display module is reduced to achieve the anti-peep effect.

Although the application has been described with reference to the above embodiments, it will be apparent to one of the ordinary skill in the art that modifications and variations to the described embodiments may be made without departing from the spirit and scope of the application. Accordingly, the scope of the application will be defined by the attached claims not by the above detailed descriptions.

What is claimed is:

1. A panel assembly, comprising:

a transparent cover comprising a lower surface;

a display module disposed under the lower surface;

a decorative layer disposed on the lower surface; and

a Fresnel lens structure located above the display module, wherein the Fresnel lens structure is formed of a portion of the transparent cover at the lower surface of the transparent cover, and

wherein the lower surface comprises a central region and a peripheral region outside the central region, and the Fresnel lens structure is only disposed corresponding to a junction of the central region and the peripheral region, the central region is rectangular and comprises a pair of long sides and a pair of short sides, the Fresnel lens structure is disposed along the pair of long sides and the pair of short sides, and a curvature of a portion of the Fresnel lens structure disposed on the pair of long sides is larger than a curvature of a portion of the Fresnel lens structure disposed on the pair of short sides.

2. The panel assembly according to claim **1**, wherein the decorative layer is disposed on the peripheral region of the lower surface.

3. The panel assembly according to claim **1**, further comprising:

a touch module disposed between the transparent cover and the display module, wherein the touch module comprises a transparent circuit region and a non-transparent circuit region.

4. The panel assembly according to claim **1**, further comprising:

a transparent adhesive layer covering the Fresnel lens structure, wherein the decorative layer is disposed on the lower surface.

5. The panel assembly according to claim **1**, wherein the Fresnel lens structure is a diverging lens or a converging lens.

6. An electronic device, comprising:

a frame;

a housing installed in the frame; and

a panel assembly installed in the frame and comprising:

a transparent cover comprising a lower surface;

a display module disposed under the lower surface;

a decorative layer disposed on the lower surface; and

a Fresnel lens structure located above the display module, wherein the Fresnel lens structure is formed of a portion of the transparent cover at the lower surface of the transparent cover, and wherein the lower surface comprises a central region and a peripheral region outside the central region, and the Fresnel lens structure is only disposed corresponding to a junction of the central region and the peripheral

region, the central region is rectangular and comprises a pair of long sides and a pair of short sides, the Fresnel lens structure is disposed along the pair of long sides and the pair of short sides, and a curvature of a portion of the Fresnel lens structure disposed on the pair of long sides is larger than a curvature of a portion of the Fresnel lens structure disposed on the pair of short sides.

7. The electronic device according to claim **6**, wherein the decorative layer is disposed on the peripheral region of the lower surface.

8. The electronic device according to claim **6**, wherein the panel assembly further comprises:

a touch module disposed between the transparent cover and the display module, wherein the touch module comprises a transparent circuit region and a non-transparent circuit region.

9. The electronic device according to claim **6**, wherein the panel assembly further comprises:

a transparent adhesive layer covering the Fresnel lens structure, wherein the decorative layer is disposed on the lower surface.

10. The electronic device according to claim **6**, wherein the Fresnel lens structure is a diverging lens or a converging lens.

* * * * *